



The National Weather Service Vision states a need to “strive to eliminate weather-related fatalities.” Their theme for 2002 was “Working Together to Save Lives.” The yearly average for weather-related fatalities in general aviation is comparable to weather fatalities due to lightning, tornadoes, and floods combined, 230 and 213, respectively. From 1995 to 2000, 4,018 people died in general aviation and small commuter aviation aircraft accidents, of which weather-related accidents accounted for 1,380 deaths. Essentially, the NTSB cited weather as a factor in three of every 10 fatal aircraft accidents during this period. These weather-related accidents accounted for 34 percent of the fatalities.

The Federal Aviation Administration’s (FAA) *Flight Service Manual* requires Flight Service Stations (FSS) to use National Weather Service (NWS) data and products when providing pilots with a flight weather briefing. As part of this briefing, the FSS specialist makes a recommendation on the appropriateness of a flight under Visual Flight Rules (VFR). If weather is observed or forecast to be Marginal VFR (MVFR) or Instrument Flight Rules (IFR), and VFR flight is doubtful, the attendant will advise the pilot “VFR Flight Not Recommended (VNR).” MVFR or IFR conditions were a factor in nearly 70 percent of the weather-related fatal accidents. In many of these cases, the pilot either chose to ignore the information provided at the weather

briefing or inadvertently flew into adverse IFR weather.

This is not just a recent problem. In a 1974 National Transportation Safety Board (NTSB) report, Special Study of Fatal Weather-involved General Aviation Accidents, the NTSB cited 2,026 fatal weather-involved accidents that killed 4,714 from 1964-72. (Weather-related or weather-involved fatal accidents refer to accidents in which the NTSB determined weather to be a cause or contributing factor in the accident.) These weather-involved accidents represented 36.6 percent of the total accidents. Similarly, in 1996 the Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation completed an extensive study of general aviation accidents for the period 1982-93. AOPA results showed a decline in the percent of weather-involved fatal accidents, from a high of 43 percent in 1982 down to a low of 24 percent in 1991. Despite the general downward trend, weather-involved accidents averaged 34 percent. Both of these studies also concluded that low ceilings, fog, and attempted VFR flight into Instrument Meteorological Conditions (IMC) were the most frequently cited cause or factor in weather-involved fatal general aviation accidents.

This quote from the August 1974 NTSB study is just as applicable today as it was 28 years ago:

“These accidents occurred with disturbing regularity despite improvements in aircraft, instrumentation, training, training facilities, the air traffic control system, weather facilities, weather services, and navigational aids.”

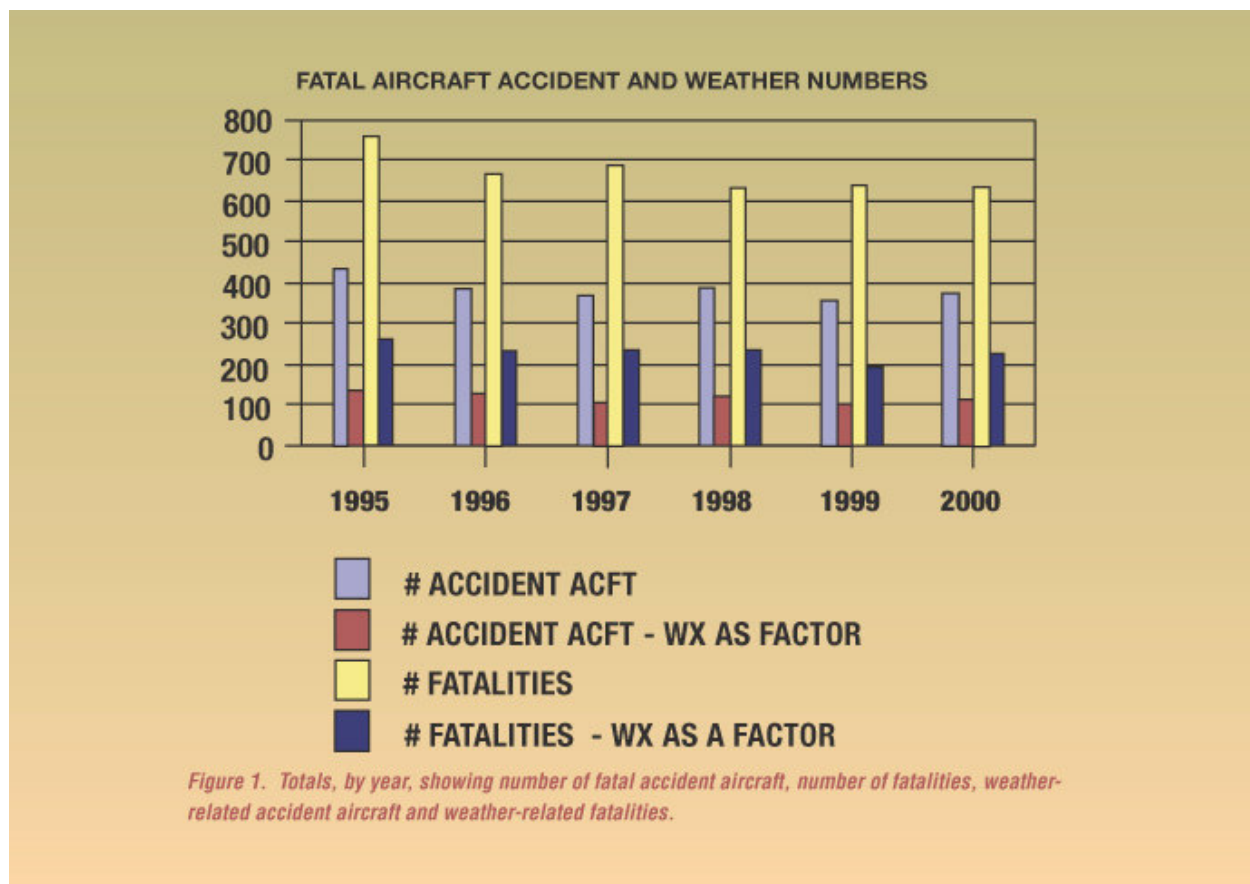
Weather-involved fatal accidents have consistently represented 30-36 percent of total fatal accidents, and although there has been a slight downward trend over the past 28 years, there remains a need to dramatically reduce these numbers.

Methodology/Data Analysis

The objective of this study was to quantify the significance of adverse weather on fatal accidents involving small aircraft that fall within the category of general and commuter aviation. The magnitude of this sector of aviation is extensive with over 200,000 registered general aviation aircraft. This class of aircraft is most vulnerable to hazardous weather or weather conditions that exceed the aircraft and/or pilot capabilities.

From 1995-2000, there are 2,605 NTSB records documenting fatal aircraft accidents. From these records, only those accidents that occurred in the United States (including Alaska and Hawaii) and its coastal waters were counted. Thus, 293 accidents were eliminated because the NTSB listed them as occurring outside the United States. Additionally, nine major air carrier accidents were eliminated, as was one duplicate record. The remaining 2,302 fatal accident reports and NTSB conclusions were thoroughly reviewed using the NTSB and the FAA National Aviation Safety Data Analysis Center (NASDAC) web sites <<http://www.nts.gov/nts/query.asp>> and <<https://www.nasdac.faa.gov>>. This six-year period of record was used in order to provide the most current data as well as allow for sufficient sample size. Furthermore, FAA NASDAC recommends using the most recent five years for safety analysis and monitoring because the

aviation industry is so dynamic and impacted by technology.



The review process initially involved accessing the NTSB accident database and doing a sort by year for all fatal accidents. The accident summary, the NTSB determined cause, and the full narrative were reviewed and the data classified. If weather was cited as a cause or factor then the following information was recorded and tabulated on a spreadsheet:

Date, number of fatalities, total pilot time, weather briefing source, location (city/state), cause of accident, weather phenomena as cause/factor, and phase of flight.

After reviewing each record from 1995-2000, the results showed weather was cited as a cause or factor in 697 fatal accidents. Note that in some cases weather was not listed as a cause or factor, but was adverse at the time of the accident. These cases were not included in the totals cited in this study, but were kept on a separate data sheet. Also, environmental conditions that favored carburetor icing and high density altitude were not included in this study but, again, were included on the separate data sheet. Finally, there were 36 accident reports that had not been finalized, most of these from 2000. Each of these preliminary reports was evaluated and only the obvious weather-related accidents were included in this study.

The final total reflects a conservative summary of weather-related fatal accidents using the following adverse weather phenomena:

Low ceiling, fog, rain, snow, turbulence, thunderstorms, icing, updrafts/downdrafts,

tailwind/crosswind, and other.

Each of these accidents was also crosschecked using the FAA NASDAC database to verify information and in some cases supplement the data collection.

Data were analyzed and summarized by month, by year, and averaged over the period of record (1995-2000). Each fatal accident report was evaluated to determine the single most likely weather event. Other weather phenomena existing at the time were labeled as two, three, and so on. Also, the impact of low ceilings and fog was considered as related weather events and combined into one category. Similarly, all wind related (turbulence, updrafts/downdrafts, and tailwind/crosswind) fatal accidents were combined. These categorizations were done to simplify the results and enable the recommendations to be targeted towards a few key areas.

Results

The results of this study focus on quantifying the significance of adverse weather in fatal aircraft accidents, highlighting the long term nature of this problem, and compiling data so targeted recommendations can be identified. A quick look at the statistics for the last six years, as presented in Figure 1, shows the numbers to be fairly consistent. There were typically 350-400 fatal accidents per year during this period, with over 600 fatalities.

Weather was a cause or contributing factor in approximately 100 of these accidents and accounted for over 200 fatalities each year. These data provide convincing evidence that adverse weather still plays a significant role in the day to day operations and decision making for pilots.

WEATHER AS A FACTOR IN FATAL AIRCRAFT ACCIDENTS

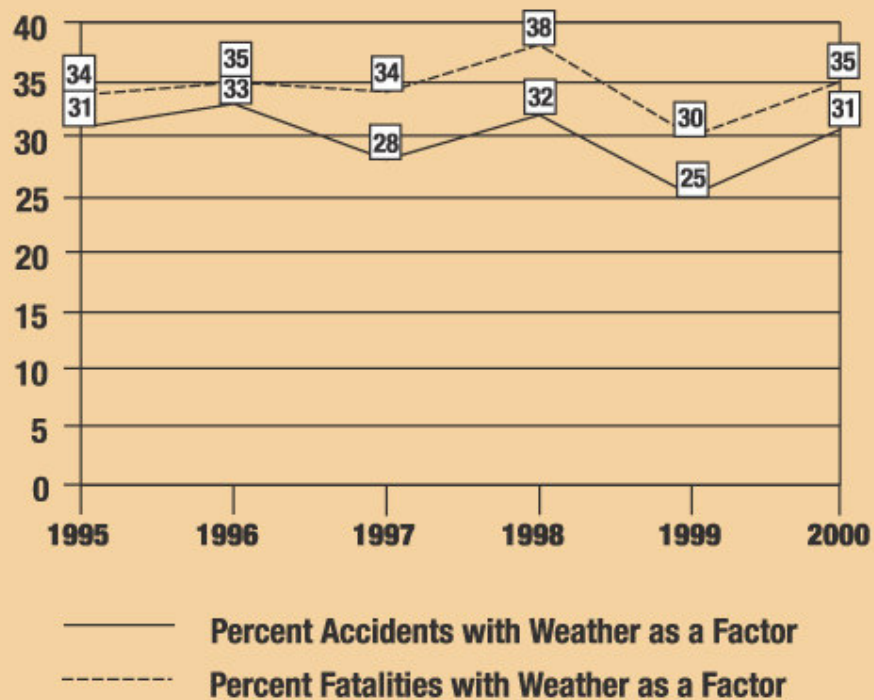


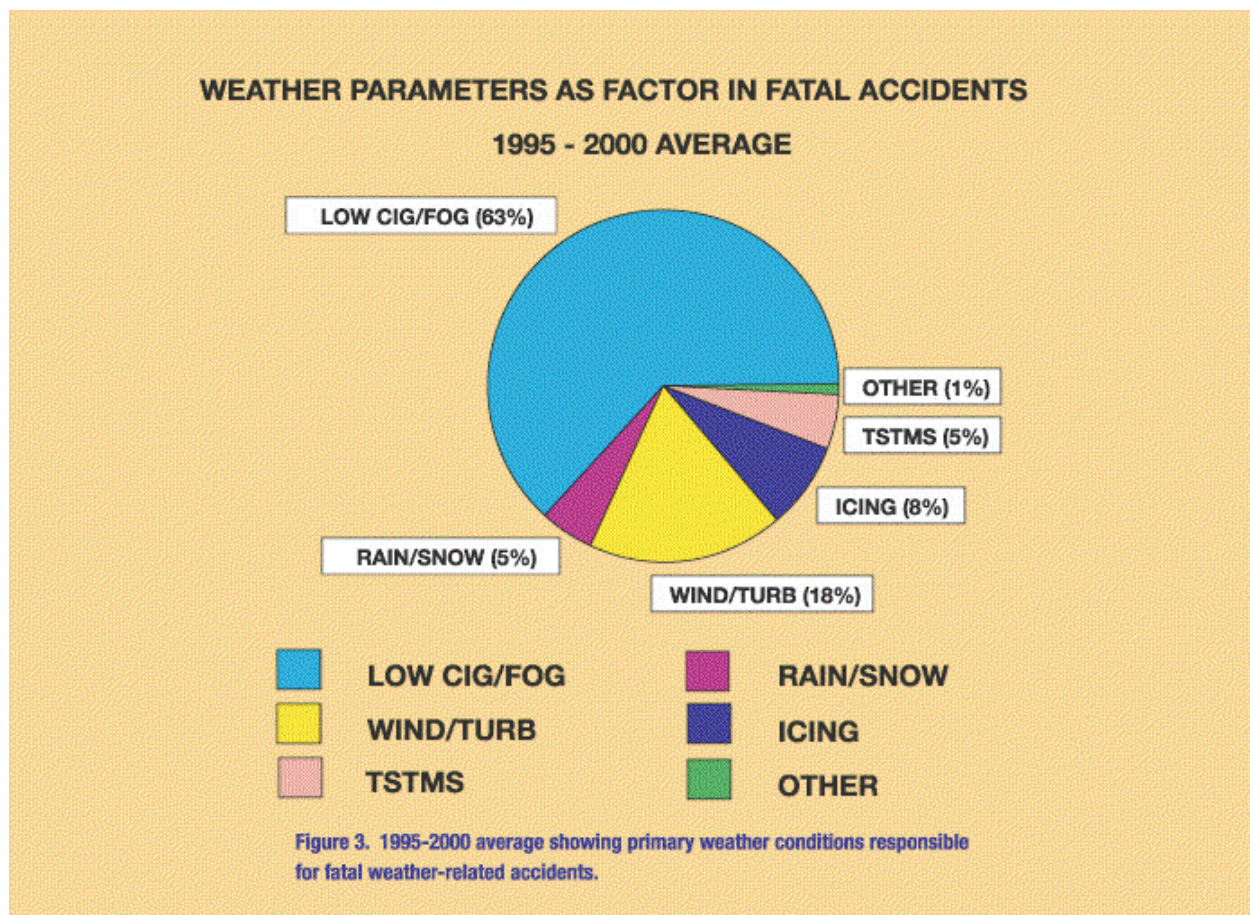
Figure 2. Percent of total accidents and fatalities, by year, in which NTSB cited weather as a cause or contributing factor.

Figure 2 is a percentage representation of the values presented in Figure 1 and shows that targeting adverse weather can provide a focus for addressing 30 to 35 percent of the accidents and fatalities. These results are consistent with earlier studies (NTSB 1974 and AOPA 1996). The concern here is that in spite of a reduction in the total number of fatalities over the past 28 years, the percentage of these fatalities that is directly related to weather has remained relatively stable. By examining the primary causes and factors involved in these fatalities, the focus of a corrective effort can quickly be narrowed down.

In reviewing each of the 697 weather-related fatal accidents, there were four causal links the NTSB repeatedly addressed in their reports. One area reviewed was the quality of NWS forecast support. This includes all surface observations across the country, the aviation forecast products and terminal forecasts produced at each of the 120 NWS Weather Forecast Offices, and the NWS Aviation Weather Center (AWC)'s advisory bulletins which include convective SIGMET's and AIRMET's for IFR/mountain obscuration and turbulence/icing. Additionally, Center Weather Advisories and Meteorological Impact Statements are issued as needed by each of the 21 Center Weather Service Units collocated at FAA Air Route Traffic Control Centers. In these accidents,

the NTSB cited NWS related weather support to be a contributing factor in only two of the accidents.

Another causal link addressed by the NTSB is the support provided to the pilot by the servicing FSS. There are nearly 3,000 FSS personnel providing weather briefing support. It is the responsibility of FSS personnel to provide the pilot with the latest available flight weather data prior to his/her making the decision to fly. Of the 697 weather-related fatal accidents, the NTSB cited FSS support as a contributing factor in only five of the fatal accidents.



A third area involves the extensive Air Traffic Control (ATC) system and the 17,000 plus personnel directing aircraft. The controllers provide vital assistance to the pilot once he/she is airborne. When a pilot inadvertently flies into adverse weather, the controllers can be the life-saving link in getting the aircraft down safely. In the accidents reviewed, ATC support was faulted as a cause or contributing factor nine times. Thus, these three causal links account for a very small fraction of weather-related fatal aircraft accidents.

The final causal link is the pilot. The decision making process and errors made by the pilot

dominate the NTSB findings. The most common pilot error was continued flight into IMC, often resulting in loss of control due to spatial disorientation. The NWS is doing its job well, the FSS personnel are providing excellent briefings, and the ATC personnel are very professional in their handling of aircraft. It is impossible to discern the exact number of lives saved, but, collectively, these agencies are saving lives every day when a pilot makes a “smart decision” based on available weather data or properly uses these services once in flight. But for all the technological advances, the advancements in forecasting, improved aircraft, rapid communication of data, and better automation in the ATC system, safe flying still boils down to the decision making process and skill of the pilot.

Figure 3 provides a summary of the weather conditions most likely to cause these fatal accidents and can help the pilot focus his/her decision making process. On the one hand, pilots most certainly have a greater understanding of the intensity and inherent danger of a thunderstorm. They respect what ice can do to an airplane’s aerodynamics. But it’s the relatively tame, and more frequently occurring, clouds and fog that are contributing to 63 percent of the weather-related fatal accidents. When this factor is combined with rain and snow, another player in the restriction of visibility, IMC problems account for nearly 70 percent of all weather-related fatal accidents. Simply stated, these pilots died because they could not see where they were going!

The AOPA’s 2000 Nall Report stated the same perplexing question when addressing VFR flight into IMC:

“What is it about the fact that they can no longer see the ground that pilots don’t understand? Because so many of these accidents were fatal, there are few surviving pilots to answer the question.”

In presenting this same issue, the *FAA Aviation News* published an article entitled “SIGMET’s, AIRMET’s, Thunderstorms, and the Force.” Though another weather-related accident is highlighted, the “Force” addresses the mysterious decision making process that faces every pilot:

“Unfortunately there is an insidious force that works to flaw our rational decision making. I’ll use the technical terminology of “it worked last time” to describe the force. Whether it is inadequate preflight planning, pushing a fuel supply, or taking a “look see” at forecast bad weather, the force often starts out weak and allows bad decisions to pass. But with each exposure the force strengthens and further clouds good decision making. Eventually the force demands a high fee and catches the unwary off guard.”

This bad decision making process often plays a role when dealing with the effects of wind, the second most significant category of weather that impacts fatal accidents. Small aircraft have lower tolerances for maneuverability and handling in strong winds. Tailwinds, crosswinds, gusty winds, updrafts/downdrafts around high terrain, and turbulence contribute to 18 percent of the fatal weather-related accidents.

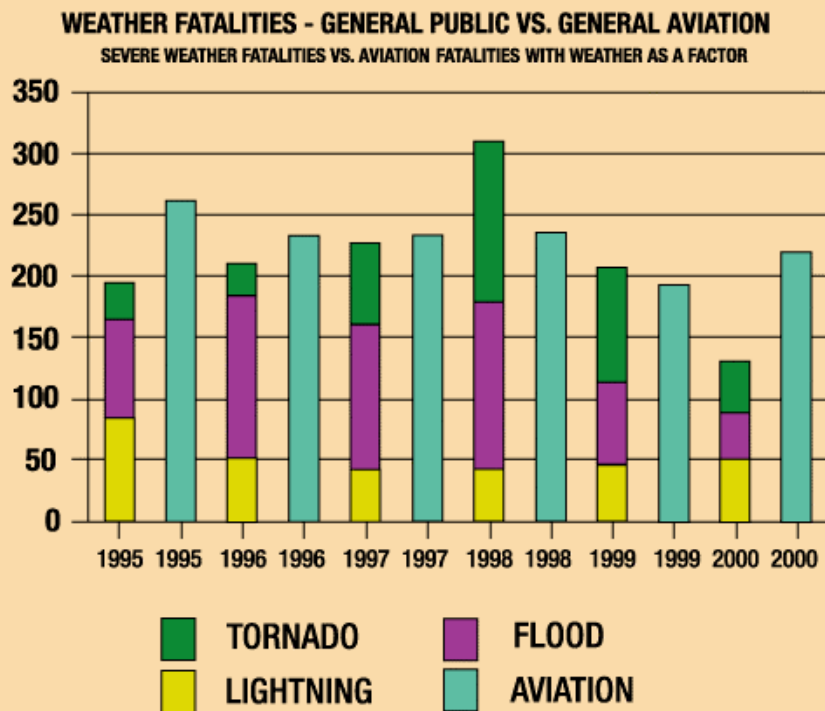


Figure 4. Comparison, by year, of weather fatalities associated with severe weather versus weather-related aviation fatalities.

Figure 4 provides a comparison of fatalities associated with the general public's vulnerability to severe weather and aviation weather-related deaths. These data show the key role the NWS plays in two essential areas of public support. By measuring the number of fatalities, it is easy to see where weather impacts the general public. Figure 4 shows that the combined number of fatalities associated with tornadoes, lightning and floods is very close to the same total of fatalities in weather-related aviation accidents; 213 and 230 per year, respectively. The U.S. Natural Hazard Statistics information on fatalities, injuries, and damages caused by weather-related hazards can be found at the following web site <<http://www.nws.noaa.gov/om/hazstats.shtml>>. Analyzing data in these two groups is not a direct comparison. Causes related to these fatalities and decision-making processes involved are quite different. Sometimes severe weather strikes and there are just helpless victims such as when a violent thunderstorm or tornado passes through a mobile home park. On the other hand, most of aviation fatalities are preventable because a conscious decision is made to take off. Both areas of public support benefit from the products and service provided by the NWS. While there are no obvious short-term trends in weather-related aviation fatalities, there has been a downward trend in severe weather fatalities over the past two years which may be partially linked to the actual frequency of severe weather. But identifying any single cause and effect of a trend is difficult, although technology, improved

equipment, better forecasts, and an aggressive public awareness campaign certainly contribute to reducing the fatalities associated with severe weather.

The four figures presented here summarize data from over 2,000 fatal general aviation and small commuter airplane accidents. These figures were presented to increase the aviation community's awareness toward IMC weather as the single most significant factor in fatal accidents. The data also provide compelling evidence showing the equal role the NWS plays in two very important areas of public support—the general public and the aviation sector.

Summary/Recommendations

The objective of this study was to show the significance of adverse weather on fatal accidents involving small aircraft. The intent was to review a large amount of data and summarize the results so efforts could be focused on a few critical areas. As presented here and in previous studies, adverse weather is a primary factor in fatal aircraft accidents. Repeatedly low ceilings, fog, or other visibility restrictions were the leading cause or a contributing factor in these fatal accidents. By all indications, the primary agencies (FAA/ATC, FAA/FSS, and NWS) responsible for supporting the pilot, in dealing with weather and aviation, are doing their job and doing it well. But it's the pilots who continue to err in their decision making process, and continue to take off or fly into IMC conditions even though they have access to the latest weather information or have received a complete pilot weather briefing.

Recommendations to remedy this problem are cited in numerous publications, agency goals, and articles. The FAA safety program, "Safer Skies – A Focused Agenda" targets weather as a safety issue for general aviation and FAA routinely carries weather safety articles in their publications. For more information on Safer Skies, see the following web site, http://www.faa.gov/apa/safer_skies/Prsrls.htm.

In a multi-agency publication, National Aviation Weather Initiatives, issued in 1999 by the Office of the Federal Coordinator for Meteorology, weather is cited as a factor in 23 percent of all aviation accidents. Annually this costs the country an estimated \$3 billion for accident damage, related injuries, and delays. This thorough assessment identified 86 initiatives to improve aviation weather safety and services. The AOPA has an aggressive education and awareness program including seminars, recurring publications and articles. The 1974 NTSB study listed 10 recommendations, seven of those dealt with pilot training or familiarization of aviation meteorology. Their report concluded stating:

"an emphasis on weather awareness is required at all levels of pilot education..."

The need for education and training concerning inadvertently entering IMC is a common theme in each of these studies, a recurring problem cited in NTSB accident reports, and the primary conclusion of this study. A special emphasis is needed for pilots with little or no IFR experience. For example, in June 1999, seven people died in Alaska because of a pilot's VFR flight into adverse weather, spatial disorientation, and failure to maintain aircraft control. The NTSB investigator asked the chief pilot of the company if he conducted any training for emergency use

of basic flight instruments. He replied that he never did and emphasized that the company's policy was to "go down and slow down but never go into instrument conditions." When asked what he would do if he found himself in an IMC situation, the chief pilot indicated he was uncertain because he never intended to be in that situation.

With limited resources, it would be logical for all agencies concerned to target the number one causal factor and use the most cost-effective approach to reduce this factor. The results of this study indicate the focus must be on the pilot's decision making process when assessing whether to fly when IMC conditions exist or are forecast.

The aviation weather safety education campaign currently in place at the FAA and AOPA would be strengthened and complemented by an added focus from the NWS. For example, an outstanding NWS web site that some pilots are not familiar with is operated by AWC and is available at <[http:// adds.aviationweather.noaa.gov](http://adds.aviationweather.noaa.gov)>. A multi-agency assault could be the difference in finally making a dent in this long-term aviation problem. In rough numbers, approximately 100 fatal crashes occur every year that are weather-related. About 70 of these 100 crashes are linked to IMC as a cause or contributing factor. An education campaign targeting this primary problem could save up to 100 lives per year or more. Perhaps a reasonable three-year goal would be a reduction in fatal crashes to 50 per year with 100 lives lost. Those numbers would be one-half of what the pilots are currently experiencing. A personal goal shared by all, however, is that this information reaches some pilot out there, and helps that pilot decide to fly smart, avoid IMC and heed the advice from FSS personnel when they say "VFR Flight Not Recommended".

I would like to extend a great deal of appreciation to Warren Rodie, Meteorologist-in-Charge of the Atlanta Center Weather Service Unit, and Lans Rothfus, Meteorologist-in-Charge of the Forecast Office, Peachtree City, GA, for their support to proceed with this effort and their insightful technical review of the results.

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